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SECOND INTERIM DEVELOPMENT REPORT

Capacitors, High KVA Transmitting
Types, Glass Dielectric

1 April - 30 June, 1953

Contract NO. NObsr-57558

Corning Glass Works Corning, N.Y.

Classification cancelled in accordance with
Executive Order 10501 issued 5 November 1953

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RESTRICTED

INTERIM DEVELOPMENT REPORT

for

CAPACITORS, HIGH KVA TRANSMITTING TYPES,
GLASS DIELECTRIC

This report covers the period April 1 to June 30, 1953.

CORNING GLASS WORKS
CORNING, NEW YORK

Navy Department Bureau of Ships Electronics Divisions

Contract NObsr-57558

June 23, 1952

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ABSTRACT

This report briefly summarizes the work under Contract NObsr-57558 for the three months ending June 30, 1953. This contract is for the development of design and production techniques of high KVA transmitting types of glass capacitors, case size designation 75 through 95. The philosophy of the design of these capacitors in glass is discussed, and cogent reasons advanced for maintaining similarities to present capacitor design. Preliminary work on evaluation of glass capacitors under the performance requirements of the contract is reported. Work so far completed, and work to be completed is presented in bar chart form, and the program for the next reporting interval is outlined.

CAPACITORS, HIGH KVA TRANSMITTING TYPES, GLASS DIELECTRIC

PURPOSE

The development of the design of transmitting types of glass capacitors with glass as the dielectric, and the establishment of manufacturing procedures for them, is the primary purpose of this contract. These transmitting types of capacitors follow the mica designation of case sizes 75 through 95. It is intended that, wherever possible, they will meet the requirements of Specification JAN-C-5 for mica capacitors. A total of 175 glass capacitors (25 each of 7 specific ratings) will be produced on straight line production facilities which will be set up and will be supplied for evaluation to the Bureau of Ships. Statements of the purpose of this work, and the requirements to be placed on it, are set forth in Ships-C-695, 14 April, 1952, which is the Specification covering this contract. Pertinent portions of it have been copied in the First Interim Report of this development. Reference should also be made to the concurrent development of medium power transmitting glass capacitors, DA36-039-sc-15509.

GENERAL FACTUAL DATA

Personnel

The following members of the Laboratory have spent the designated amount of time on this contract during this reporting period:

Randels, Dr. R. B., Research Associate	62 hrs.
Fabian, O. W., Junior Research Physicist	105 hrs.
Sprague, L. G., Research Electrical Engineer	214 hrs.
Carlton, Mrs. K., Research Assistant	39 hrs.
Connor, Mrs. E., Junior Research Assistant	183 hrs.
Engler, Miss B., Junior Research Assistant	83 hrs.
Uncapher, Mrs. L., Junior Research Assistant	47 hrs.
Arnold, Mrs. M., Laboratory Assistant	168 hrs.
Gee, G. E., Laboratory Assistant	32 hrs.
Smith, Dr. G. P., Senior Research Associate	98 hrs.

Detail Factual Data

1. Case and mounting of the capacitors.

The glass transmitting capacitors of the high voltage, high current types to be developed and placed in production under this contract, will be made of many sealed units connected together. The electrical requirements dictate that for the thicknesses of dielectric of the order of a few thousandths of an inch which are most convenient for this work, the connection be a series-parallel array, for most of the specified ratings. The ease with which series-connected dielectrics can be built into a single capacitor stack in glass by including equipotential plates within the glass matrix makes the idea of construction of such high voltage stacks a very attractive one. This is discussed in some detail in the First Interim Report, and a possible design for such a capacitor is sketched as Figure 14 of that report.

The construction of this capacitor requires that several constructional problems be solved: a good terminal lug must be attached to the capacitor stack; for high capacitances, and for close control of lower capacitances, it will be desirable to put at least two pre-measured capacitor stacks in parallel at each position; and these composite stacks must behave satisfactorily. Therefore, a program, parallel in some respects to the concurrent work under the Signal Corps Contract mentioned above, was carried out to solve these problems.

a. Terminals.

The type of heavy terminals shown in Figure 13 of the First Interim Report for capacitor stacks resulted in junctions of dissimilar metals in fairly closely confined spaces. This has been considered to be unsatisfactory, and a redesign has been effected in which an aluminum terminal has been embedded within the glass matrix. The aluminum is of sufficient thickness to meet mechanical requirements (.010" to .015"). This thickness introduces an intolerable amount of stress if the aluminum is sealed to the glass, so it is prevented from sealing by enclosing it with very thin foils of aluminum, which do seal. The heavy lug is held in place mechanically by shaping it in any desirable manner. This has included punching holes in it, so that a glass rivet is actually formed, or by indenting or corrugating it, or a combination of these.

b. Stack assembly.

If two or more stacks are to be placed in parallel in an exposed assembly of this kind, they must either be physically spaced far enough apart so that moisture or other extraneous material can not be trapped between them, or they must be sealed together. Two methods for this sealing have been evolved: by sealing the components together in the same furnace in which they were originally sealed, or by sealing them together with a softer, "solder glass". The change in capacitance has been found to be a nearly negligible amount, which is

subject to close control, for either method. Losses on assembly from voltage failure have also been of negligible importance.

c. Testing.

Capacitors sealed together in pairs as described, and with lugs of several experimental types, have been checked electrically by the usual tests including life test, and mechanically by vibration tests. There were no failures in about 40 such composite groups on life test at 85°C for the standard 1000 hours. There were no failures with any of the lug designs tried, for the standard five hour vibration. A complete answer to the vibration question can of course not be obtained until completely assembled capacitors are tested.

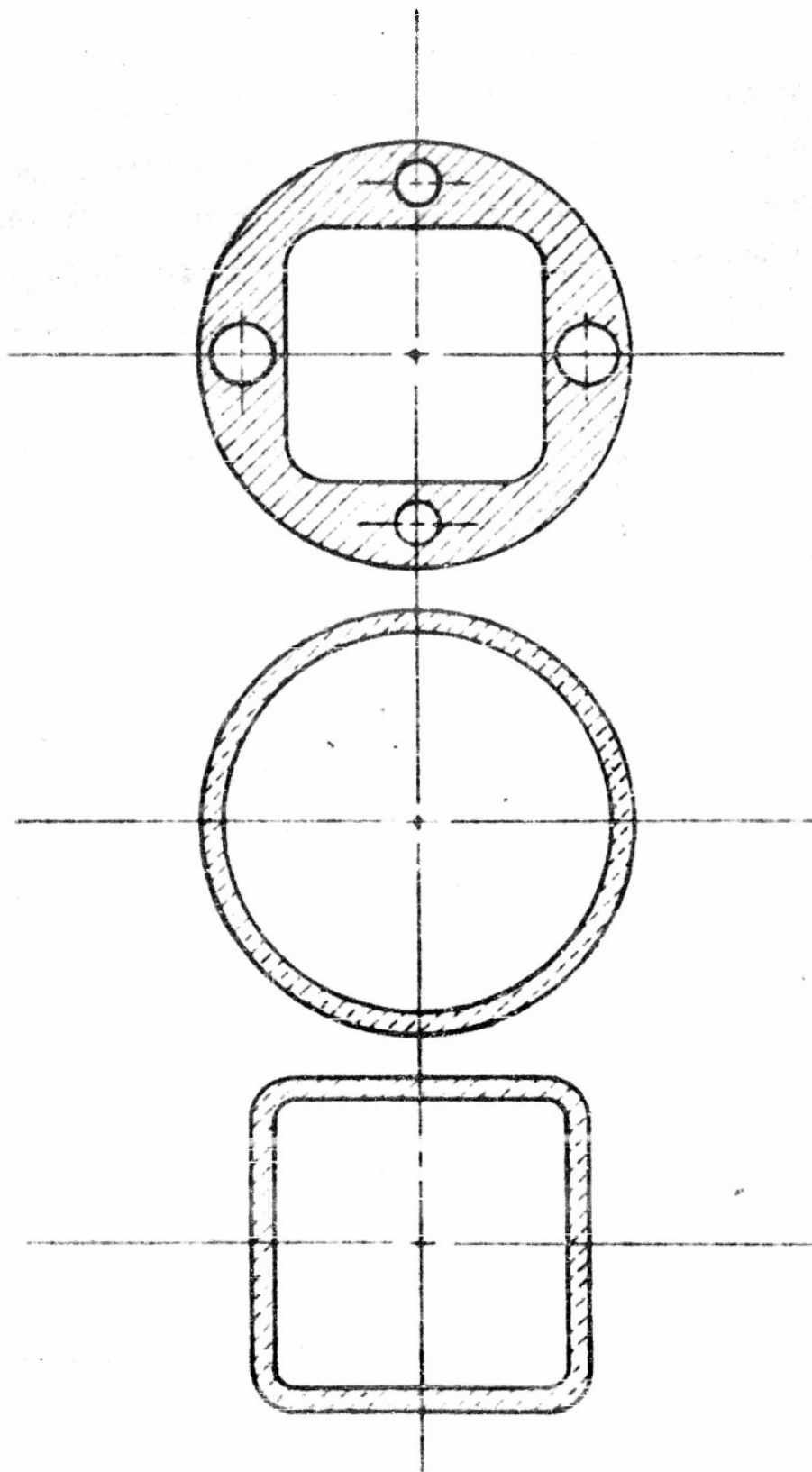
The kind of capacitor design discussed above has several advantages over the conventional form of housed capacitor: it is much lighter in weight, cooling of the stacks is much more efficient, and it requires less material. It also has several disadvantages: it is more fragile, it is not an exact counterpart of the capacitor it is intended to replace, and it is not as well adapted to production. This last item has some importance. If the finished capacitors are made in the conventional form with the elements completely enclosed by and potted in a cylindrical enclosure, these elements or stacks may also be made in the conventional manner, in which all the electrodes are active ones. The general design of stacking machine developed for pig-tail

capacitors under the partial sponsorship of Navy Contract NObs-5221 can be adapted for stacks of this kind, but design of a machine to make shielding foil stacks would be much more difficult.

The components of such a capacitor are each well sealed, therefore no yokes or clamps are necessary to assure that shifts do not occur in the dielectric layers. A glass case may be soldered to the conducting ends, and no provision need be made for the usual gasketting arrangement. This means that a much greater percentage of the total volume can be made available for the capacitor elements. Figure 1 shows a sketch of one CM75 case. This is compared to a case which could be used for glass capacitors. The approximate area is seen to be about $2\frac{1}{4}$ square inches compared to 4. The capacitor elements will of course be rectangular, so that much of the space within a cylindrical enclosure is wasted. If the glass enclosure is made rectangular or square in cross-section, the amount of space available is seen to be about 3 square inches, if it is made to fit within the same circle. This should allow greater freedom of mechanical design.

2. Electrical design of capacitor components.

The electrical design of the components will be simplified if they are of the conventional type. An analysis of the requirements as detailed in the First Interim Report shows that the specified AC voltages for the capacitors decrease markedly as the capacitance increases. Even



*GLASS ENCLOSURE FOR GLASS CAPACITOR
COMPARED TO PRESENT CERAMIC ENCLOSURE*

Figure 1

greater however, is the decrease in the specified radio-frequency voltages with increase of capacitance. These in general determine the design because of the desirability of operating the capacitor below the corona voltage of the components. Designing these capacitors with shielding foil components will result in a large number of different component designs. If the series connections are made outside the stacks rather than within them, this can be reduced to a much smaller number.

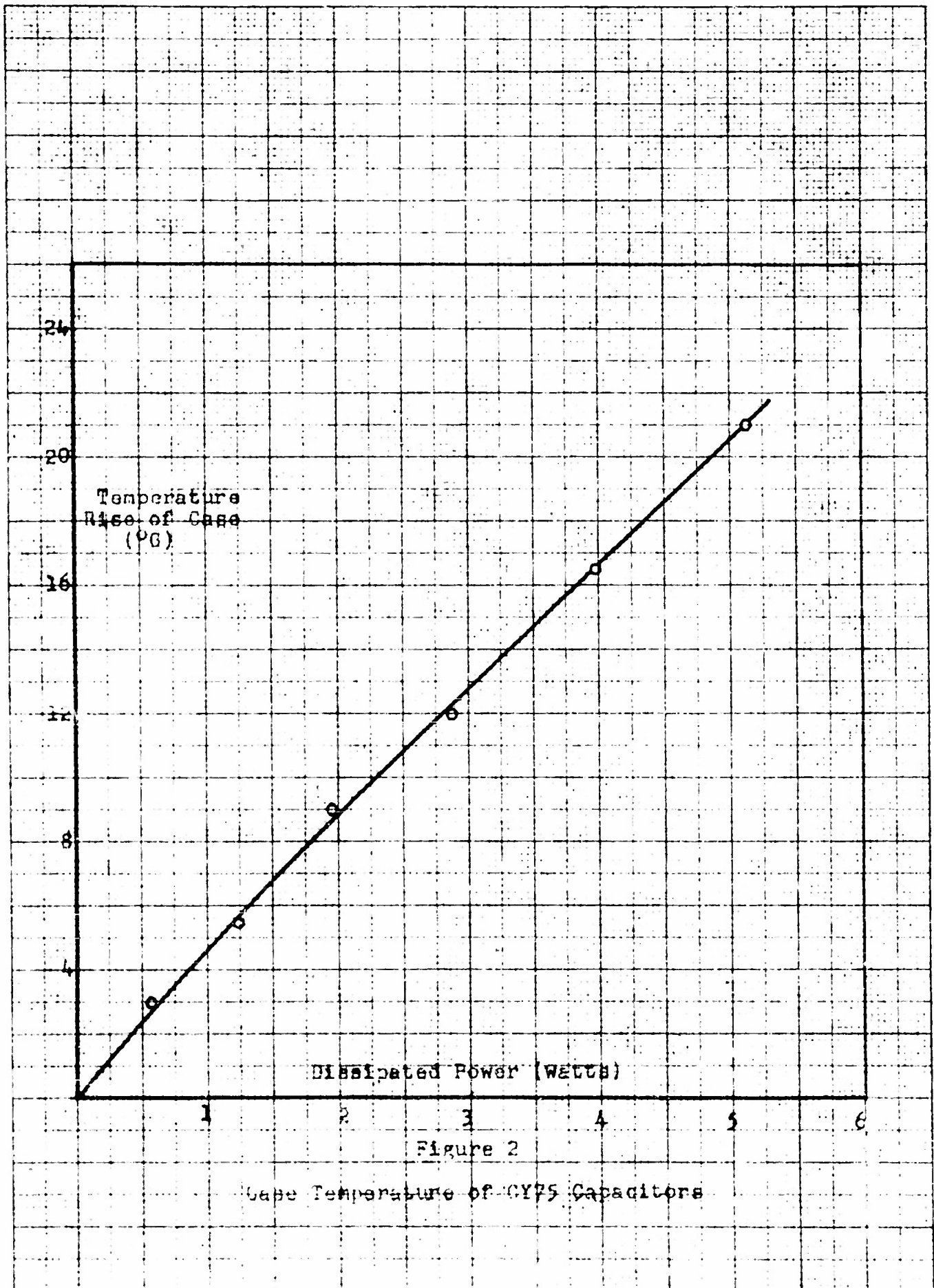
The requirements for CM75 show that the specified radiofrequency power is greatest at 1 megacycle in the region of 1000 mmfd, and at .3 megacycle in the region of 10000 mmfd. CY75 capacitors are now being made for initial studies of their radiofrequency behavior under the specified conditions. Assuming an average onset of corona voltage of 350 to 400 volts for capacitors made with dielectric nominally .0027" thick, and a safe rating in life test of at least 875 volts AC, reference to Figure 1 of the First Interim Report shows that at 1000 mmfd the corona voltage determines the design, and at 10,000 mmfd the dielectric strength is the limiting factor. The 1000 mmfd capacitors for test are therefore made with 8 capacitor stacks in series, and those at 10,000 mmfd with 5. Test samples are also being made at the maximum capacitance listed, 100000 mmfd, with 2 capacitors in series.

The equilibrium rise in temperature under specified operating conditions at radiofrequencies will be a measure of the operating power factor of these capacitors.

The real power generated can be inferred from temperature rise measurements on a capacitor case containing a resistor. The results for a dummy CY75 are shown in Figure 2. The power necessary to heat this case, of approximately 33 square inches exposed area, to 15°C at equilibrium, is about 3.6 watts. Table 1 shows that the specifications require that the power factor must be no greater than .023 percent under conditions of greatest power. Values for the larger case sizes have been inferred from these results, and are included in the table for comparison. They will of course be checked by actual measurement on these sizes.

Table 1

Case Size	Maximum Reactive Power	Capacitance at Maximum Power	Surface Area (sq. in.)	Watts for 15°C Rise	Maximum Allowable Power Factor
75	15680va.	1300 mmfd	33.	3.6	.00023
80	22200	2400	57.	(6.2)	(.00028)
85	37800	5600	102.	(11.1)	(.00029)
90	59500	2000	142.	(15.5)	(.00026)
95	122500	5600	284.	(31.)	(.00025)



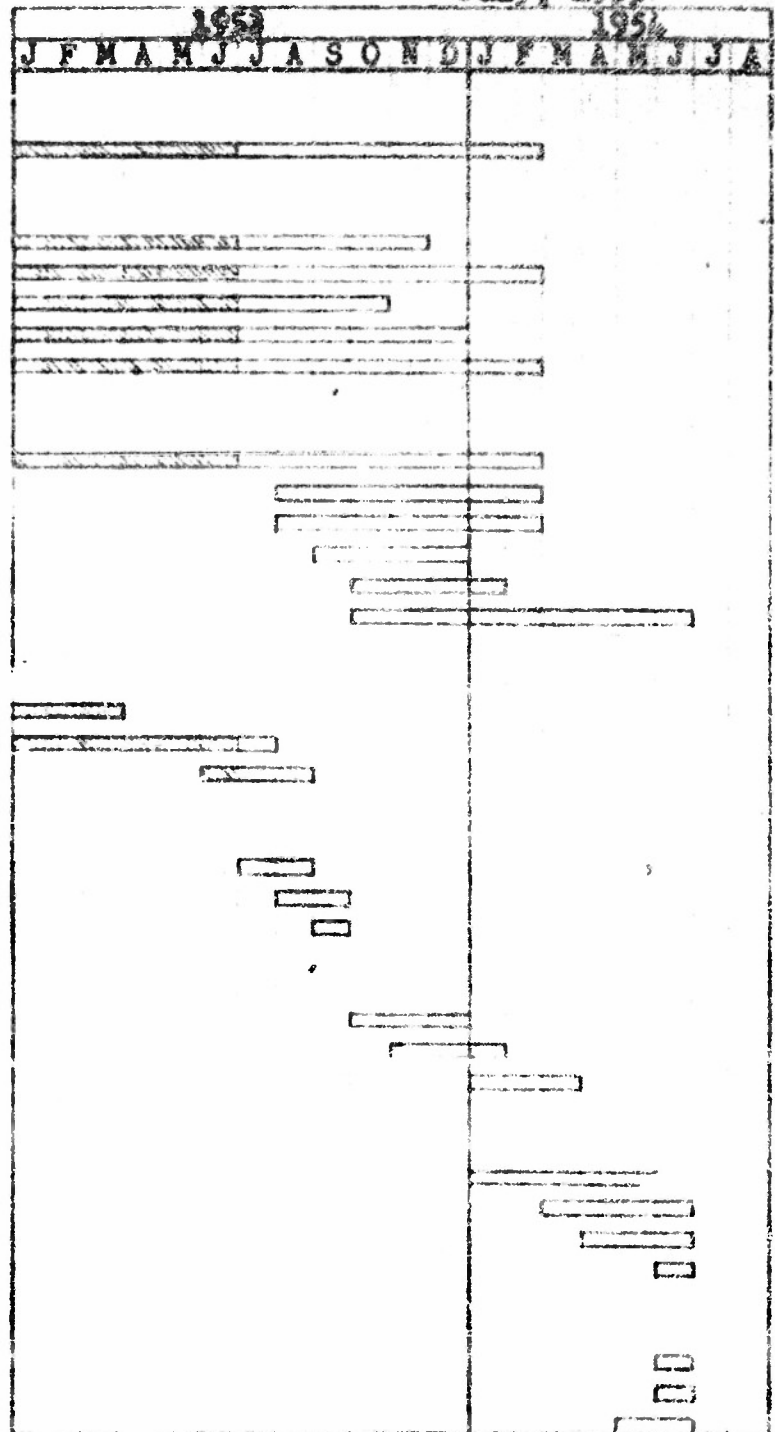
CORNING GLASS WORKS

PROJECT PERFORMANCE and SCHEDULE

Contract NObar-57558

July, 1953

1. Background, correlation with concurrent research
2. Component (stack) design
 - Design and development
 - Dielectric strength test
 - Corona voltage tests
 - Radiofrequency tests
 - Life tests
3. Capacitor design
 - Design and development
 - Dielectric strength test
 - Radiofrequency tests
 - Vibration tests
 - Moisture tests
 - Life tests
4. Radiofrequency oscillator*
 - Design
 - Obtain material and build
 - Test
5. Life test equipment*
 - Design
 - Obtain material and build
 - Test
6. Production facilities
 - Layout
 - Obtain & build equipment
 - Complete facilities
7. Production of capacitors
 - Components
 - Capacitors
 - Performance tests
 - Delivery
8. Other engineering
 - Final report
 - Microfilm
 - Patent disclosures



*Necessary for performance tests, but to be supplied by Corning Glass Works.

Figure 3

PROGRAM FOR NEXT INTERVAL

During the next reporting interval we expect to begin the evaluation of the performance of capacitors in the several capacitance sizes constructed as described in the body of this report. Additional life test equipment will be designed and constructed for determining the behavior of component stacks as well as of completed capacitors. The design of the components, as well as of the completed capacitors will be continued, and it is hoped that the general design can be defined within this reporting period. This work will continue to be interrelated with work on medium power capacitors sizes 55 through 70, under DA36-039-sc-15509.

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